IMERG: Background and Early Results

The GPM Multi-Satellite Team

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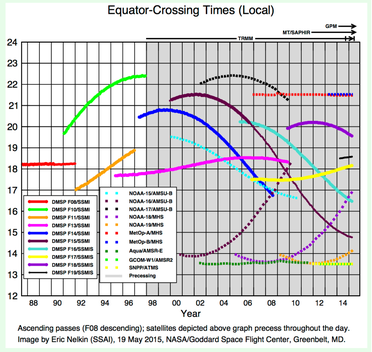
THE CURRENT IMERG MICROWAVE CONSTELLATION

The original goal was 3-hourly observations, globally
- Original basis was sampling the diurnal cycle
- But also, morphed microwave loses skill outside ±90 minuntes

The current IMERG constellation includes:
- 6 polar-orbit passive microwave imagers
  - 4 SSMIS, AMSR-2, GMI
- 4 polar-orbit passive microwave sounders
  - 4 MHS

The future is "interesting"
- 2 additional passive microwave sounders soon
  - SAPHIR (asynchronous), ATMS (polar)
- Legacy satellites are allowed to drift
  - apparently 06/18 (00/12) UTC is a stable (unstable) point
  - exact coverage is a complicated function of time
  - duplicate orbits aren't very useful for getting 3-hourly observations
- CGMS is studying placing a satellite in the 00/12 UTC gap in coverage
- GPM fuel may last >10 years
- Launch manifests are sparse



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day.
Image by Eric Nelkin (SSAI), 19 May 2015, NASA/Goddard Space Flight Center, Greenbelt, MD.

IMERG DESIGN PHILOSOPHY

IMERG is a unified U.S. algorithm that takes advantage of the strengths of the partner algorithms

- Kalman Filter CMORPH – CPC/NOAA
  - Lagrangian time interpolation
  - Kalman statistical weighintg
- PERSIANN with Cloud Classification System – U.C.-Irvine
  - Infrared-based precipitation
- TMPA – GSFC NASA
  - Satellite intercalibration
  - Gauge combination
- All three partners have received PMM support
- Precipitation Processing System (PPS, GSFC/NASA)
  - Computes/assembles input data sets
  - Generates IMERG products
  - Archives IMERG products
- IMERG is a single integrated code system appropriate for near-real and post-real time
- "The devil is in the details"

The Japanese merged-satellite counterpart is GSMaP

IMERG DATA REQUIREMENTS/GOALS

Resolution – 0.1° [i.e., roughly the resolution of microwave, IR footprints]

Time interval – 30 min. [i.e., the geo-satellite interval]

Spatial domain – global, initially covering 60°N-60°S

Time domain – 1998-present; later explore entire DMSP era (1987-present)

Product sequence – early sat. (~6 hr), late sat. (~16 hr), final sat.-gauge (~3 months after month) [more data in longer-latency products]

Sensor precipitation products intercalibrated to GPM GMI/DPR combined (2BCMB)

Global, monthly gauge analyses including retrospective product – explore use in submonthly-to-daily and near-real-time products

Error estimates – still open for definition

Embedded data fields showing how the estimates were computed

Precipitation type estimates – probability of liquid

Operationally feasible, robust to data drop-outs and (strongly) changing constellation

Output in HDF5 v1.8 – compatible with NetCDF4

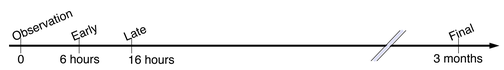
Archiving and reprocessing for near- and post-RT products

IMERG Data Fields

	Half-hourly data file (Early, Late, Final)
1	*[multi-sat.] precipitationCal*
2	[multi-sat.] precipitationUncal
3	*[multi-sat. precip] randomError*
4	[PMW] HQprecipitation
5	[PMW] HQprecipSource [identifier]
6	[PMW] HQobservationTime
7	IRprecipitation
8	IRkalmanFilterWeight
9	*probabilityLiquidPrecipitation [phase]*
	Monthly data file (Final)
1	*[sat.-gauge] precipitation*
2	*[sat.-gauge precip] randomError*
3	GaugeRelativeWeighting
4	*probabilityLiquidPrecipitation [phase]*

IMERG RUN STRATEGY

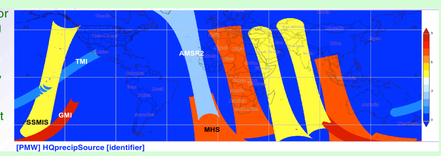
Different users have different requirements for latency and accuracy
- "Early" – forward-only morphing 6 hours after observation time for users needing a quick answer (flash flooding, landslides)
- "Late" – a complete forward/backward morphing 16 hours after observation time for "next-day" users (agricultural forecasting)
- "Final" – combined multi-satellite and gauge analyses 3 months after observation for archival science research data (climate statistics, model validation)
- Terminology based on NWS weather map analysis cycle



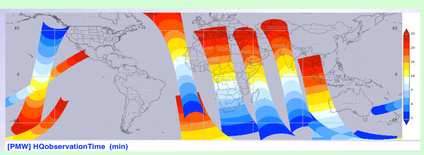
Studies underway for reducing near-real-time latency
- Even the 6-hour latency for the Early run requires compromises
  - only enough microwave data arrives to do forward morphing
  - there is only a limited amount of forward data for computing the motion vectors
- A shorter latency has been requested – say, 2 hours
  - formally, this is possible using whatever data have arrived by the time the computation is done
  - each half hour builds on the previous, so there is no way for late-arriving data to get into the system
  - need to use the state at a previous time, say 2 hours earlier, as the base and compute forward to the new half-hour

SELECTED IMERG HALF-HOURLY OUTPUT FIELDS
1430 – 1500Z 3 April 2014

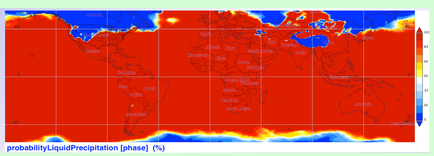
PMW sensor contributing the data, selected as imager first, then sounder, then closest to center time



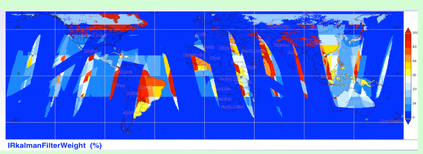
PMW sensor observation time after start of half hour



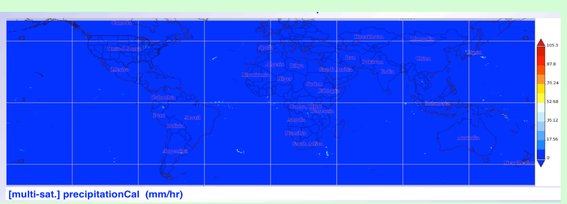
probability that precipitation phase is liquid; diagnostic computed from ancillary data



weighting of IR in the Kalman filter step



"Final" IMERG field: forward and backward morphed microwave, Kalman filter with IR data; monthly gauge

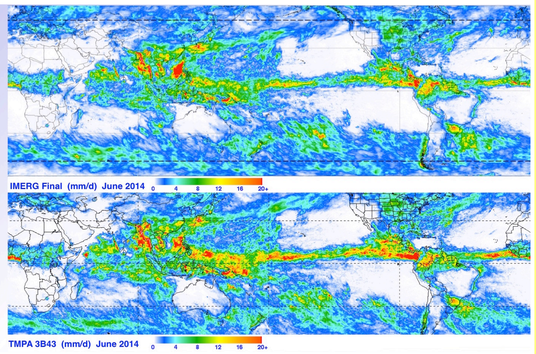


PRELIMINARY VALIDATION RESULTS

IMERG Final Run vs. 3B43 for June 2014

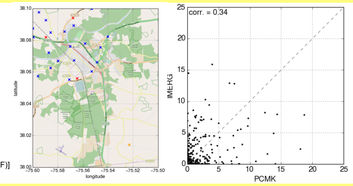
Same input satellites, different algorithms, different calibrator
- 2BCMB vs. 2B31

Similar features, but not identical
- features (SPCZ)
- bias (ITCZ)



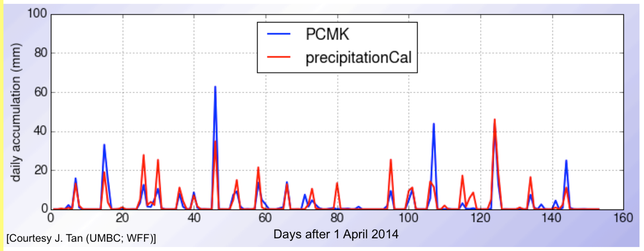
Hourly IMERG and Pocamoke Gauge Network Fine-Scale Grid, April-August 2014

- 20 surface gauges in a 6x5 km region near Wallops Island, Virginia
- Instantaneous correlation is modest, as expected
- Treating PCMK as true for entire IMERG grid box introduces slight additional error



[Courtesy J. Tan (UMBC; WFF)]

Daily IMERG and Pocamoke Fine-Scale Grid, April-August 2014

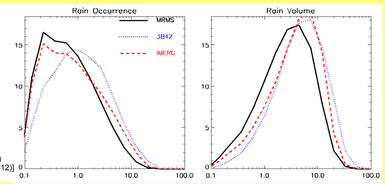


[Courtesy J. Tan (UMBC; WFF)]

- Temporal sampling improves performance
- Excellent correlation for most events (warm season)
- Both over- and under-estimates for largest events

3-Hourly, 0.25° IMERG, 3B42, MRMS for 15 June 2014

- Multi-Radar Multi-Sensor (MRMS) state-of-the art radar-gauge over CONUS
- IMERG better than 3B42 for precipitation occurrence
- IMERG performs modestly better for precipitation volume



[Courtesy J. Wang (SSAI; NASA/GSFC 612)]

SCHEDULE AND FINAL REMARKS

IMERG is becoming available
- Final Run for mid-March to January 2015
- Late Run from 7 March 2015
- Early Run from 1 April 2015

Early 2016: first-generation GPM-based IMERG archive, March 2014–present

Early 2017: first-generation TRMM/GPM-based IMERG archive, 1998–present

IMERG Data Access
- IMERG data is freely available
- PPS Access- http://pmm.nasa.gov/data-access/downloads/gpm (registration is quick and automated)
- GDISC Access - http://mirador.gsfc.nasa.gov/cgi-bin/mirador/presentNavigation.pl?tree=project&project=GPM

Real Time SVS IMERG Data Animation - http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4285

IMERG Email List - contact David Bolvin at david.t.bolvin@nasa.gov to be added